Russia's Policies and Approach to Plutonium Management, Use and Disposition

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RUSSIA'S POLICIES AND APPROACH TO PLUTONIUM MANAGEMENT, USE AND DISPOSITION

This paper reviews Russia's policies and approach to management, use and disposition of plutonium, including weapons grade plutonium Russia inherited from the Soviet Union nuclear weapons program and civilian plutonium obtained as a result of reprocessing of spent nuclear fuel from Russia's nuclear power plants and other reactors and subcritical assemblies. This paper briefly covers the history of the Russian plutonium program, inventory of weapons grade and civilian plutonium, status of plutonium related infrastructure, and Russian policies affecting plutonium inventories and flows, including Russian position on managing excess weapons plutonium, nuclear fuel cycle policies affecting stocks of civilian plutonium and Russian reaction to the U.S. plutonium management policies, specifically, dilute-and-dispose approach to handling excess weapons plutonium and announcement of plutonium pit production at the Savannah River Site.

Russia has substantial stocks of both weapons grade plutonium and civilian plutonium obtained through reprocessing of spent nuclear fuel from nuclear power plants. Inventories, stream and infrastructures related to these two categories of plutonium do not intersect at the moment. Weapons grade plutonium does not cross into civilian nuclear fuel cycle, while civilian plutonium does not feed military program. The U.S.-Russian Plutonium Management and Disposition Agreement signed in 2000 would facilitate transfer of excess weapons plutonium to civilian nuclear energy production. However, as implementation of this Agreement is suspended, Russian weapons grade plutonium subject to the Agreement is in passive storage.

RUSSIAN PLUTONIUM INVENTORY

Russia has stockpiles of both weapons grade plutonium generated over 1948-2010 by plutonium production reactors specifically built for defense purposes and reactor grade plutonium generated in civil reactors both operable and decommissioned, and other nuclear facilities.

Starting 1948 until the end of weapons grade plutonium production in 2010 Russia had accumulated 128±8 tons of weapons grade plutonium[1,2] for use within the framework of its nuclear weapons program. Russia does not report any information regarding quantities of its weapons grade plutonium. Most authoritative estimate is provided by the International Panel on Fissile Materials, independent group of arms-control and nonproliferation experts from both nuclear weapon and non-nuclear weapon states. This estimate is based on calculation of amounts of plutonium produced by each reactor taking into account the available data and reasonable assumptions on reactor design and plutonium production capacity, upgrades made to reactors to increase plutonium production capacity, reactors operation history, including frequency of reloads, repairs and accidents, as well as total operation time. The estimate also takes into account plutonium losses calculated based on data on the design and operation history of facilities for plutonium separation and pits production, as well as data on nuclear tests, and nuclear weapons lost with sunken nuclear submarines. Data on the design of reactors and other facilities, as well as their operation history are available from various publicly available sources, including archive documents related to nuclear weapons program, research, and memories of people that used to work within plutonium production program. Russia has unclassified and published many such documents over the last three decades[3].

15 tons of 128 tons is plutonium dioxide in storage at Mining and Chemical Combine (MCC). This is plutonium extracted since 1997 from irradiated fuel of last three Russian production reactors shut down in 2008-2010 within the framework of the U.S.-Russian cooperation on plutonium production reactors.

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[1] International Panel on Fissile Materials. Countries: Russia, URL: http://fissilematerials.org/countries/russia.html

[2] Anatoli Dyakov. The History of Plutonium Production in Russia. Science & Global Security, 19, no. 1, 2011 URL: http://scienceandglobalsecurity.org/archive/sgs19diakov.pdf

[3] Part of these documents are available in dedicated Rosatom electronic library: USSR Atomic Project. Documents and Materials. URL: http://elib.biblioatom.ru/sections/0201/

Another 25 tons is plutonium in pits stored at Fissile Material Storage Facility at Mayak constructed with substantial funding and expert support from the U.S. Russia committed to not using these 40 tons of plutonium for nuclear weapons programs and assigned at least 34 out of these 40 tons for disposal within the framework of the U.S.-Russian Plutonium Management and Disposition Agreement. However, no weapons grade plutonium has been disposed and Russia continues storing it. Details regarding the management of plutonium referred to in this paragraph are available below.

88 of 128±8 tons of weapons grade plutonium are available for nuclear weapons programs. Part of this plutonium is in weapons. Other plutonium is strategic stockpile necessary to maintain and upgrade nuclear weapons, as well as plutonium pits removed from nuclear warheads for remanufacturing necessary due to pits deterioration during storage[4]. We assume that this plutonium is stored and processed at Mayak, as Mayak is currently the only Russian site with capability to fabricate and refabricate plutonium pits.

Russia also has substantial stockpiles of civilian plutonium produced in various types of power reactors. Russia reports its amounts of civilian plutonium following commitments to the Guidelines for the Management of Plutonium (INFCIRC/549[5]). In addition to reporting Russia's commitment under INFCIRC/549 include storing separated civil plutonium only at reprocessing or fuel fabrication plants, or at limited number of other sites specifically designated by the Government. According to Russia's reporting under the INFCIRC/549 amount of civilian plutonium continuously grow, including the amount of separated plutonium (see table below). Most plutonium is contained in spent nuclear fuel stored at storage facilities of MCC and Mayak.

[4] Oleg Bukharin. A Breakdown of Breakout: U.S. and Russian Warhead Production Capabilities URL: https://www.armscontrol.org/act/2002-10/features/breakdown-breakout-us-russian-warhead-production-capabilities

[5] https://www.iaea.org/publications/documents/infcircs/communication-received-certain-member-states-concerning-their-policies-regarding-management-plutonium

Table 1 - Civilian Pu inventory, tons, based on INFCIRC/549 reporting

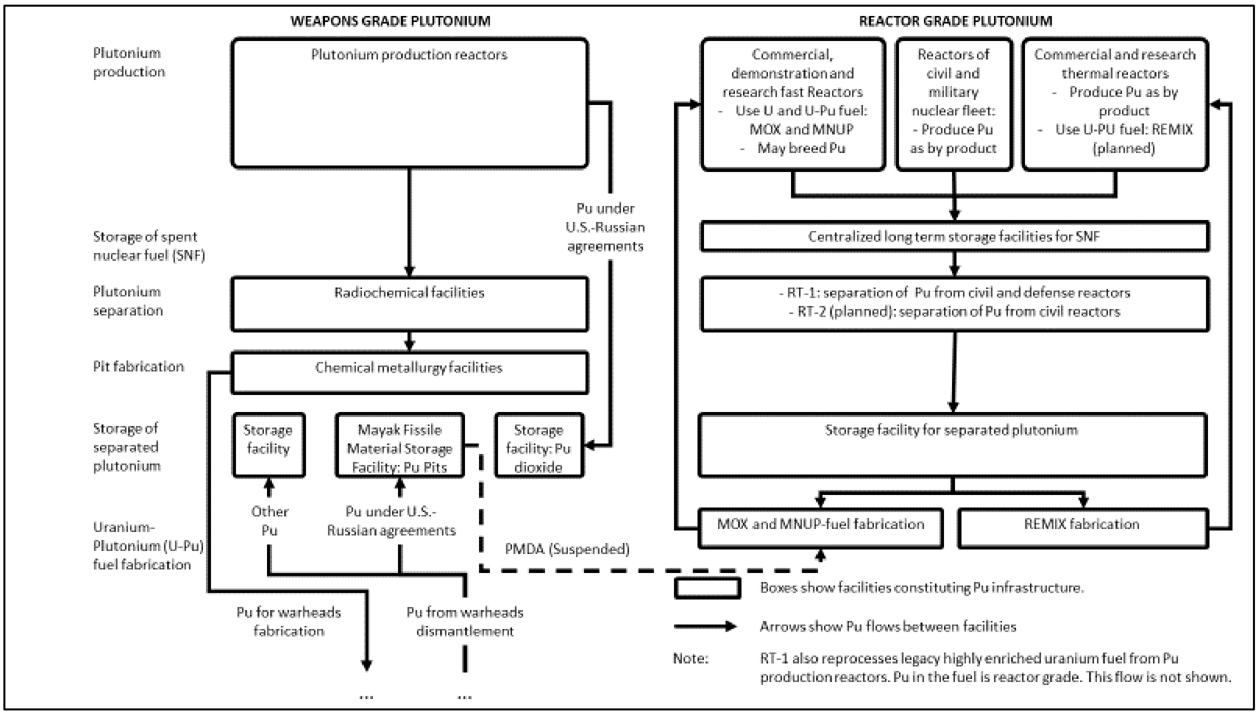
	2018	2017	2016	2015	2014	2013	2012	2011	Note
Separated	56.5	56.7	54.9	53.1	52.0	50.3	49.2	48.1	Growth is presumably indicative of RT-1 reprocessing plant output
Separated in fabrication	1.2	-	-	-	-	-	-	-	
MOX	3.2	1.8	*1.7*	*1.5*	0.3	0.4	0.3	0.3	We assume that significant increase of quantities of Pu in MOX is caused by fabrication of test and regular loads for BN-800
Elsewhere	0.4	0.5	0.6	0.8	1.3	1.2	1.2	1.1	
SNF@NPP sites	79.0	78.0	78.0	78.0	79.0	79.0	77.5	75.5	This includes SNF in reactor cooling ponds and in dry storage facilities of NPPs with graphite-moderated reactors
SNF@ reprocessing plants	4.0	3.0	4.0	5.0	5.0	4.5	4.5	4.0	We assume that this relates to SNF transferred to reprocessing facilities for reprocessing
SNF@non-NPP storage	84.0	78.0	73.0	68.0	62.5	56.5	53.0	51.5	This includes SNF stored outside NPPs (at Mayak and MCC storage facilities)
Total	228,3	218,0	212,2	206,4	200,1	191,9	185,7	180,5	

RUSSIA'S APPROACH TO MANAGE WEAPONS GRADE PLUTONIUM

Russia's approach toward managing weapons grade plutonium can be captured in a set of following principles[6]:

- Maintain inventory and production capabilities at the level necessary to support strategic nuclear forces and maintain credible deterrence.
- Downsize legacy production complex to the level adequate to current needs, while safely decommission legacy infrastructure to reduce maintenance costs and environment impact.
- Dispose weapons grade plutonium declared excess to defense needs on a mutual basis with the U.S. While agreement governing the U.S. and Russia cooperation on this issue is currently suspended, Russia announced that plutonium under the agreement would not be used for defense purposes[7].
- Weapons grade plutonium to be disposed should be burnt in nuclear power plants reactor as a component of mixed-oxide (MOX) fuel.

Soviet Union had developed vast production capabilities intended to produce plutonium for Russian nuclear weapons program. This infrastructure (see picture below) included 13 plutonium production reactors located at Mayak, Mining and Chemical Combine (MCC) and Siberian Chemical Combine (SCC). Plutonium produced in these reactors was separated from the spent nuclear fuel at reprocessing facilities located at the same sites and then sent to production of plutonium pits at chemical metallurgy plants at Mayak and SCC. Plutonium pits were then sent to weapons assembly/disassembly plants to become part of nuclear weapon. Newest weapons grade plutonium infrastructure facility is Fissile Material Storage Facility (FMSF) commissioned in 2003. FMSF was built with the U.S. financial support to provide secure storage for nuclear materials from dismantled nuclear weapons. All nuclear fuel cycle facilities involved in producing and managing weapons grade plutonium and their status are listed in the Table 2 in Appendix.



[6] These principles as presented are not captured in any official document. Rather they constitute this paper authors' understanding of Russian plutonium management policy based on available documents and developments related to plutonium infrastructure.

[7] President Order #511 of October 3, 2016 On the Suspension of Agreement Between the Government of the United States of America and the Government of the Russian Federation Concerning the Management and Disposition of Plutonium Designated as No Longer Required for Defense Purposes and Related Cooperation and Protocols to This Agreement. URL: http://www.kremlin.ru/acts/bank/41288

USSR and Russia as USSR successor had shut down most plutonium production reactors by early 1990s. The last three reactors were shut down in late 2000s with the U.S. support. Details regarding the history of reactors shutdown and respective U.S. Russia cooperation are available below, as well as current status of reactors, reprocessing facilities and chemical metallurgy plants.

Decommissioning of Plutonium Production Reactors

Soviet Union started shutting down plutonium production reactors in late eighties. Ten out of thirteen reactors were shut down over 1987-1992[8]. Reasons behind the shutdown included decrease in the need for additional plutonium due to arms reductions under the U.S.-Soviet Union Intermediate-Range Nuclear Forces Treaty of 1987 and Strategic Arms Reduction Treaty of 1991, as well as moratorium on nuclear weapons tests put by Russia in 1991. Additional reasons also included economic crisis after the collapse of the Soviet Union that significantly reduced money allocated to deference, including nuclear weapons. In addition, expert community and public had safety concerns raised due to Chernobyl accident in 1986 and publication of information regarding radiological accidents associated with plutonium production and weapons tests in early 90s.

The remaining three reactors - one reactor at Mining Chemical Combine (MCC) and two reactors at Siberian Chemical Combine (SCC) - were dual purpose reactors. In addition to producing plutonium these reactors also supplied electricity and heat to nearby closed cities. These reactors were shut down within the framework of the U.S.-Russian Agreement on Cooperation Regarding Plutonium Production Reactors signed on September 23, 1997 and amended in 2003. The U.S. and Russia obliged to cooperate to shut down remaining MCC and SCC reactors and pledged not to restart plutonium production reactors shut down before and after signing the agreement. The initial agreement signed in 1997 defined that SCC and MCC reactors would be modified using the U.S. funding and expert support to stop production of weapons grade plutonium and continue operation as sources of heat and electricity until the end of reactors' service life. 2003 amendment and following consultations tied shut down to the development of fossil fuel replacement power plants in closed cities hosting MCC and SCC to cover energy needs that were covered by plutonium production reactors. The reactors were not modified and continued producing weapons grade plutonium, but Russia pledged not to use plutonium produced after 1995 and extracted after 1997 to fabricate nuclear weapons. The U.S. committed funding and management support for the development of fossil power replacement plants.

Parties also agreed on mutual verification inspections and other monitoring procedures. This included inspections at SCC and MCC to verify that shut down of their reactors goes as agreed and plutonium produced by the reactors over remaining operation time is not used in weapons programs, as well as inspections at the U.S. and Russian reactors shut down earlier to verify that reactors are not restarted. This also included monitoring plutonium from SCC and MCC reactors mentioned above by the U.S. Parties also agreed to terminate inspections to shut down reactors after the reactors are dismantled in a way that guarantees that reactors cannot not be restarted to produce plutonium.

Construction of fossil replacement power plants and shut down of SCC and MCC reactors under this agreement had been fully competed by 2010. Spent fuel was completely removed from the reactors. Plutonium extracted from irradiated fuel of MCC and SCC reactors subject to the agreement was eventually consolidated at MCC site for further storage[9].

According to the current Russia's plan shut down reactors will be subject to on-site disposal. This includes dismantlement of reactor building and removal of most reactor parts, and filling up reactor shaft including graphite cladding and nearby compartments with concrete and special mixture of natural clays. This approach to disposal is suitable for other reactors due to similar design, however respective techniques

[8] Anatoli Dyakov. The History of Plutonium Production in Russia. Science & Global Security, 19, no. 1, 2011 URL: http://scienceandglobalsecurity.org/archive/sgs19diakov.pdf
[9] International Panel on Fissile Materials. Countries: Russia, URL: http://fissilematerials.org/countries/russia.html

and procedures may need case by case adjustments due to different environmental and geological conditions, as well as different radiation levels and state of the reactor materials and nearby structures[10].

Pilot on site disposal of I-2 SCC reactor was accomplished in 2011-2015. Preparatory work included development of special techniques for management of radioactive waste, facilities for preparation of clay mix and filling up technique, development of digital models of disposed reactor and simulation and safety monitoring software, as well as development of justifications and acquisition of necessary licenses. Experience and lessons learned from I-2 disposal serves as a basis for further work on disposing other reactors. Additional efforts also included preparations for disposal of certain reactors at Mayak, MCC and SCC sites made over 2010-2015. This included necessary surveys, safety justifications, licensing and other pre-design activities.

Disposal activities are scheduled to complete by 2030. These activities include further disposal of plutonium production reactors, as well as disposal of fuel fabrication facility at Novosibirsk Chemical Concentrates Plant that used to fabricate nuclear fuel for plutonium production reactors and various research facilities used for studies related to plutonium production, separation and use.

On site disposal of shut down plutonium production reactors is funded from the Russian federal budget. E.g., costs for pilot disposal of I-2 SCC plutonium production reactor were 2.3 billion Rubles[11] (approx. USD 31.6 million as of the end of 2015, when project was complete).

Radiochemical plants

All radiochemical plants used to separate plutonium from the spent nuclear fuel irradiated in plutonium production reactors are shut down. Mayak radiochemical facility was shut down in 1987[12]. After that Mayak shipped irradiated fuel to SCC radiochemical facility. SCC and MCC used their radiochemical facilities until the shut down of last plutonium production reactors at these sites in 2008 and 2010 respectfully. Last batches of irradiated fuel from plutonium production reactors were loaded into SCC and MCC radiochemical facilities in 2008[13], and 2012[14] respectfully.

Currently all facilities are not used and will be subject to disposal. SCC, Mayak and MCC conducted preliminary surveys related to disposal of these facilities in 2010-2015. Disposal of these facilities is now part of a program funded from the Russian Federal Budget.

In 2017, SCC reported on the development of concept of disposal of its radiochemical facilities used to separate weapons-grade plutonium. As of the beginning of 2020, SCC had completely removed nuclear material and removable radioactive waste from the facilities and cleaned up technology equipment to the extent possible[15]. Currently SCC and Rosatom continue maintaining safety and security of the facilities.

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[10] Rosatom Report on Progress Towards Disposal of Nuclear Legacy over 2008-2015 http://xn---2030-bwe0hj7au5h.xn--p1ai/upload/iblock/41c/41c3ea1ec996498711c3fb21364a27d3.pdf

[11] 20.06.2017 Mystery of Irradiated Graphite. Strana Rosatom (Rosatom news-paper). URL: https://strana-rosatom.ru/2017/06/20/%d1%82%d0%b0%d0%b9%d0%bd%d0%b0-%d0%be%d0%b1%d0%bb%d1%83%d1%87%d0%b5%d0%bd%d0%bd%d0%be%d0%b3%d0%be-%d0%b3%d1%80%d0%b0%d1%84%d0%b8%d1%82%d0%b0/

[12] Novoselov V.N. Atomic Heart of Russia. – 2014 ISBN 978-5-98518-053-4 URL: http://elib.biblioatom.ru/text/novoselov_atomnoe-serdtse-rossii_2014/go,4/?bookhl=%D1%81%D0%B8%D0%B1%D0%B8%D1%80%D1%81%D0%BA%D0%B8%D0%B9%2A

[13] 13.05.2020 Rosatom will allocate money for disposal of SCC chemical metallurgy facility. URL: https://www.atomic-energy.ru/news/2020/05/13/103578

[14] 05.03/2012 Last Batch of Irradicated Standard Uranium Blocks Was Loaded in MCC Radiochemical Plant URL: https://www.sibghk.ru/news/3763-%D0%BD%D0%B0-%D1%80%D1%85%D0%B7-%D0%B3%D1%85%D0%BA-%D0%BF%D1%80%D0%BE%D0%B8%D0%B7%D0%B2%D0%B5%D0%B4%D0%B5%D0%BD%D0%B0-%D0%B7%D0%B0%D0%B3%D1%80%D1%83%D0%B7%D0%BA%D0%B0-%D0%BF%D0%BE%D1%81%D0%BB%D0%B5%D0%B4%D0%BD%D0%B5%D0%B9-%D0%BF%D0%B0%D1%80%D1%82%D0%B8%D0%B8-%D0%BE%D1%81%D1%83%D0%B1.html

[15] 18.01.2017 SCC Plans to Dispose Part of Its Radiochemical Plant URL: СХК планирует вывод из эксплуатации части РХЗ, занимавшейся"оборонкой" - РИА Томск (riatomsk.ru)

Over 2020, Rosatom awarded two contracts on implementing safety and security measures at these facilities. The contracts at a total cost 2.3 billion Rubles (USD $31.3 million) cover one year, second half of 2020 and the first half of 2021. Funding for the contracts was allocated from federal budget. In addition to ensuring safety and security at radiochemical facilities, the contracts also include similar works at shut down SCC chemical metallurgy facilities. Price breakdown is not available. We assume that Rosatom will award similar contracts over the next years until the start of facilities disposal projects.

SCC Radiochemical Plant hosting shut down radiochemical facilities and associated infrastructure continues operation of civil facilities for purification of natural and regenerated civil uranium

Mayak had completed detailed survey of its radiochemical facilities used to separate weapons-grade plutonium by the beginning of 2019. In 2019-2020 Mayak worked to design disposal projects and obtain necessary licenses for disposal of part of the facilities. Over 2020, Rosatom awarded large contracts for works on decommissioning Mayak facilities and infrastructure used for separation of weapons grade plutonium. Total contracts price is 509.8 million Rubles (USD $ 6.7 million)[16]. Money were allocated from the Russian federal budget.

MCC started preparing for disposal of its radiochemical facility used to separate weapons grade plutonium in 2010 by removing radioactive pulps from tanks used in plutonium separation process. In 2019 MCC prepared design and licensing documentation for the first stage of four-stages disposal of remaining radioactive waste, equipment and buildings[17].

Plutonium pits production/Chemical metallurgy plants

SCC chemical metallurgy facilities used in weapons programs was completely shut down in 2017 for further disposal upon respective Rosatom decision[18]. Since 2017, SCC and Rosatom have been working using federal budget funding to cleanup the facilities so that they pose no nuclear safety risks. Chemical Metallurgy Plant hosting shut down chemical metallurgy facilities continues operation as part of civil programs. In particular, the Plant is used as a basis for the development of experimental fabrication of uranium-plutonium fuel for civil fast thermal and reactors (BREST/MNUP and REMIX fuel)[19] (see below).

Mayak chemical metallurgy plant is the only chemical metallurgy plant in operation in Russia. Mayak is designated as Federal Nucler Organization and continues activities related to the development, disposal and maintenance of nuclear weapons[20] at this plant. We assume that this includes regular remanufacturing plutonium pits necessary due to pits deterioration during storage[21]. Mayak upgraded the plant in 2000s-2010s.

Organization and funding support for decommissioning of weapons-grade plutonium infrastructure

Rosatom highlights importance of elimination of legacy plutonium infrastructure referring to high cost of maintenance of the infrastructure that puts substantial financial burden on Rosatom organizations operating the facilities, as federal budget only covers about one third of such expenses. Another issue

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[16] Procurement Notifications of March 19, August 9, and October 29, 2020 URL:
https://zakupki.gov.ru/epz/order/notice/ea44/view/common-info.html?regNumber=0773100000320000027,
https://zakupki.gov.ru/epz/order/notice/ea44/view/common-info.html?regNumber=0773100000320000087,
https://zakupki.gov.ru/epz/order/notice/ea44/view/common-info.html?regNumber=0773100000320000100

[17] 17.05.2019 Начался вывод из эксплуатации радиохимического завода ГХК
http://xn---2030-bwe0hj7au5h.xn--p1ai/society/news/nachalsya-vyvod-iz-ekspluatatsii-radiokhimicheskogo-zavoda-gkhk/

[18] 08.08.2016 SCC Chemical Metallurgy Plant Will be Disposed in Serversk URL: https://zato.tv/news/5315

[19] SCC Fabricated Experimental MUP Fuel Assemblies URL:http://proryv2020.ru/news/na-sibirskom-khimicheskom-kombinate-iz/

[20] Novoselov V.N. Atomic Heart of Russia. – 2014 ISBN 978-5-98518-053-4 URL:
http://elib.biblioatom.ru/text/novoselov_atomnoe-serdtse-rossii_2014/go,4/?bookhl=%D1%81%D0%B8%D0%B1%D0%B8%D1%80%D1%81%D0%BA%D0%B8%D0%B9%2A

[21] Oleg Bukharin. A Breakdown of Breakout: U.S. and Russian Warhead Production Capabilities URL:
https://www.armscontrol.org/act/2002-10/features/breakdown-breakout-us-russian-warhead-production-capabilities

driving speed up of elimination of legacy infrastructure is deterioration of legacy facilities that may cause serious safety incidents in the future[22]

Shut down facilities subject to decommissioning belong to and operated by Rosatom nuclear fuel cycle enterprises – SCC, MCC and Mayak. However, actual activities at these facilities, including decommissioning and maintaining safety and security at most of the facilities awaiting decommissioning, are implemented by the specially established Pilot Demonstration Center for Disposal of Uranium Graphite Reactors that is co-located with SCC. The intent behind the establishment of the Center was to build strong expertise needed to effectively dispose uranium graphite reactors, including plutonium production reactors, and piloting respective technologies at SCC reactors. Objectives of Pilot Demonstration Center include maintenance of shut down SCC plutonium production reactors, designing reactor disposal programs, disposal of the reactors and use of acquired expertise to support similar works at MCC and Mayak, as well as providing services related to disposal of nuclear facilities and nuclear waste to nuclear operators in Russia and abroad. MCC and Mayak remain operators of their shut down reactors and involve Pilot Demonstration Center as contractor for work related to disposition of plutonium production infrastructure as necessary.

These activities are funded from the Russian budget through Federal Targeted Programs – designated budget mechanism intended to fund multiyear complex projects requiring substantial financial investments. Based on publicly available budget reporting, over 2016-2020 Rostom organizations received at least 60 billion rubles (approx. USD 787.4 million as of December 1, 2020) from federal budget for disposal activities and will receive about 215 billion Rubles (approx. USD 2.8 billion as of December 1, 2020) over the next seven years, 2021-2027[23].

MANAGEMENT OF EXCESS WEAPONS-GRADE PLUTONIUM

Russia's approach to manage plutonium that is excess to defense needs have been evolving together with the U.S.-Russian cooperation on this issue. Several other countries worked together with Russia to study various options for excess weapons-grade plutonium disposition, but ultimately these developments were triggered by the U.S.-Russian disarmament efforts that made substantial amounts of plutonium unnecessary for defense needs.

Presidents Clinton and Yeltsin in their Joint Statement Between the United States and Russia on Nonproliferation of Weapons of Mass Destruction and Means of Their Delivery made in Moscow on January 14, 1994 "tasked their experts to study options for the long-term disposition of fissile materials, particularly of plutonium, taking into account the issues of nonproliferation, environmental protection, safety, and technical and economic factors" and "reaffirmed the intention of interested organizations of the two countries to complete within a short time a joint study of the possibilities of terminating the production of weapon-grade plutonium". Joint study was accomplished by the U.S.-Russian Independent Scientific Commission on Disposition of Excess Weapons Plutonium in 1996-1997 and its final report[24] provided the roadmap for future cooperation on the issue of excess weapons plutonium. More than 20 years after the Study its recommendations proved to be too ambitious and have not been fully implemented. However, several of those recommendations had substantial impact on the U.S.-Russian cooperation on plutonium disposition and current Russia's approach to this issue. These recommendations include:

- Disposing plutonium "using the plutonium in mixed oxide (MOX) fuel for burning once-through in currently operating nuclear power reactors, and vitrifying the plutonium together with fission products in glass logs"

[22] 19.05.2018 На АтомЭкспо-2018 объявили о разработке федерального закона о ядерном наследии http://xn---2030-bwe0hj7au5h.xn--p1ai/society/news/na-atomekspo-2018-obyavili-o-razrabotke-federalnogo-zakona-o-yadernom-nasledii/

[23] Постановление Правительства РФ от 2 июня 2014 г. N 506-12 "Об утверждении государственной программы Российской Федерации "Развитие атомного энергопромышленного комплекса"

[24] https://clintonwhitehouse4.archives.gov/textonly/WH/EOP/OSTP/html/Holdren.html

- "Increased transparency about the inventories of nuclear warheads and nuclear-explosive materials possessed by the United States and Russia, and about the steps being taken to reduce these inventories"
- Agreement that "the U.S. and Russian programs of warhead dismantlement and management and disposition of the associated nuclear-explosive materials should continue to proceed in parallel, seeking to complete comparable steps in this process on comparable time scales"
- Agreement that "the United States and Russia should move quickly to implement and expand on the reciprocal information exchanges and mutual inspections related to nuclear stockpiles that have been agreed to in principle, to help ensure the transparency and irreversibility of nuclear arms reductions".
- Acknowledgement that "the United States, Russia, and the international community should begin now to address the largest obstacle to progress on plutonium disposition beyond interim storage, which is financing and constructing adequate capacity in the two countries for processing plutonium pits into plutonium oxide and for fabricating plutonium and uranium oxides into MOX fuel".
- Agreement that "the United States and Russia should move as quickly as practicable to end additional production of weapons plutonium, including providing the necessary financing to complete their cooperative project to convert the cores of the plutonium production reactors at Seversk (Tomsk-7) and Zeleznogorsk (Krasnoyarsk-26)".

These recommendations have either been implemented (see outline of the effort to shut down plutonium production reactors above) or substantially contributed to the evolution of Russia's approach to managing excess weapons plutonium.

In September 1997 Russian President Boris Yeltsin in its address to the IAEA General Conference announced Russia's decision "to carry out the gradual withdrawal from nuclear defence programmes of up to 500 tonnes of highly enriched uranium and up to 50 tonnes ofplutonium released in the nuclear disarmament process"[25].

Mayak Fissile Materials Storage Facility

First cooperative effort related to plutonium management was focused on construction of Fissile Material Storage Facility (FMSF) at Mayak intended to provide safe and secure storage of weapons grade plutonium and highly enriched uranium from dismantled nuclear weapons. The U.S. funded the construction under the dedicated agreement between the U.S. and Russia signed on October 5, 1992 as implementing agreement to the umbrella CTR agreement. The FMSF was commissioned in 2003. Minatom (now Rosatom) loaded the facility with 25 tons of plutonium from nuclear warheads subject to the U.S.-Russian cooperative efforts on disposition of weapons grade plutonium outlined below and refused loading other weapons grade plutonium into the facility although the FMSF can store total of 50 tons of plutonium. This raised concerns on the U.S. side regarding the ineffective use of resources allocated by the U.S.[26] There are evidences suggesting that Mayak continues operating FMSF, storing plutonium in it and maintaining security systems. E.g. Mayak awarded 6.4 million Rubles (USD $ 84,551.2) contract on upgrade of FMSF PP system in September 2020.

Trilateral Initiative

To address transparency concerns, the U.S., Russia and IEAE established joint project known as Trilateral Initiative. The project established in 1996 and ended in 2002 was aimed at developing and negotiating mutually acceptable verification techniques and procedures to be used by IAEA. The Trilateral Initiative

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[25] https://www.iaea.org/sites/default/files/gc/gc41or-3_en.pdf

[26] Report of the U.S. Government Accountability Office. DOE's Effort to Close Russia's Plutonium Production Reactors Faces Challenges, and Final Shutdown Is Uncertain. Published: Jun 4, 2004. Publicly Released: Jun 4, 2004. URL: https://www.gao.gov/assets/250/242706.pdf

reached substantial progress in developing verification techniques, including the developing and piloting attribute measurement system with information barrier capable to verify declared plutonium attributed in yes/no manner without disclosure of sensitive information to inspector. After the wrap up of the initiative, parties continued technical exchanges and discussions on verification technologies, but no legally binding verification arrangements were made.

Scientific and Technical Cooperation

The U.S. and Russia concluded Scientific and Technical Cooperation Agreement to streamline R&D works related to plutonium disposition started in early 90s. Recommendations of the Joint Study outlined above needed practical validation of identified plutonium disposition options. The U.S. committed funding and expert support for developing and upgrading facilities in Russia, as well as conducting research necessary to validate possibility of disposition of plutonium by converting it to spent nuclear fuel standard through the use in existing power reactors, including pressurized water reactors VVER-1000, the most common reactor type in Russia, Russia's operated fast reactor BN-600 and then under construction BN-800.

Activities under the Technical Cooperation Agreement included:

- Upgrading and developing facilities for converting plutonium derived from nuclear weapons into MOX fuel using vibropacking – pyrochemical technology in Research Institute of Atomic Reactors (RIAR) and test irradiation of this fuel in BN-600 and BOR-60 research fast reactor operated by RIAR.
- Support to safety studies and licensing of MOX-fuel fabrication and use, changes to BN-600 design needed to make the reactor suitable for plutonium disposition, as well as operation of VVER-1000 reactors with MOX core.
- Upgrading and developing facilities for industrial scale fabrication of pellet MOX fuel for fast reactors at MCC and Mayak sites.
- R&D related to disposition of nuclear waste produced by facilities used for plutonium disposition.

In addition to support from the U.S. these works were supported by Germany, France and Japan.

Plutonium Management and Disposition Agreement

Under the PMDA concluded in 2000 the U.S. and Russia agreed to dispose at least 34 tons of weapons grade plutonium each. Russian plutonium subject to disposition included 9 out of 15 tons of plutonium from irradiated fuel of MCC and SCC plutonium production reactors stored at MCC site and 25 tons of plutonium from dismantled nuclear weapons stored at Mayak Fissile Material Storage Facility

After signing the original PMDA, the U.S. and Russia continued discussing approach to disposition captured in the agreement. According to the revised version of the agreement that entered into forces in 2011, Russian wepons plutonium should be disposed by using it to fabricate MOX fuel that should be used in fast reactors BN-600 and BN-800. VVER-1000 option was abandoned, including due to safety concerns, as MOX fuel loaded in the reactors would significantly reduce effectiveness of neutron absorbers used for reactor control and emergency shutdown[27]. The U.S. committed financial support for further development of necessary infrastructure. This includes the development of MOX fuel fabrication facility, modification of BN-600 reactor to remove breeding blanket, as well as finalizing design of BN-800 reactor. The use of the U.S. funding for construction of BN-800 reactor was directly prohibited by the agreement. Completion of all preparatory works and start of plutonium disposition was scheduled to 2018.

By 2020 Russia has reached significant progress in developing MOX fabrication capabilities, had operable BN-800 reactor, piloted the use of MOX fuel made from reactor grade plutonium in the reactor together with uranium fuel, and started transitioning the reactor to MOX fuel. As of the end of 2020 Russia has full

[27] E.g. see Semechkov Yuriy. VVER Fuel: Status and Perspectives. Rosenergoatom Journal issue #11 of November 2014 URL: http://nrcki.ru/files/pdf/1463658870.pdf

scale production of MOX fuel at MCC capable to supply fuel sufficient for regular reloads of BN-800 over its service life.

Although these capabilities allow disposing weapons grade plutonium, Russia did not start the disposal due to suspension of PMDA in 2016. According to respective President Order N 511 of October 3, 2016 and comments that the RF Ministry of International Affairs released in 2019[28] , Russia suspended the PMDA referring to lack of progress in the development of agreed infrastructure for disposing U.S. weapons grade plutonium, as well as changing agreed disposition strategy without proper reconciliation with Russia.

Russia also did not make changes to BN-600 required by PMDA to use the reactor as disposition facility, including removal of side reactor blanket. The reactor will not likely be transferred to MOX fuel neither from MCC nor form RIAR and will be operated using uranium fuel until the end of its service life. Currently Russia uses the reactor for test irradiation of plutonium-uranium nitride fuel for demonstration lead-cooled reactor constructed at SCC and REMIX fuel for Russian PWRs made from uranium-plutonium mix regenerated from SNF (see below). RIAR vibropacked MOX fuel production capabilities will likely be used for producing fuel for BOR-60 reactor until the end of its service life. They also were used to fabricate MOX fuel for the first load of BN-800 reactor. Further fuel loads will include pellet MOX-fuel manufactured at MCC only.

MANAGEMENT OF PLUTONIUM IN CIVIL NUCLEAR FUEL CYCLE

Russian policy towards use of civil plutonium is driven by the long standing nuclear energy policy aimed at development of closed nuclear fuel cycle. This policy implies nuclear energy system consisting of the following key components:

- Thermal reactors (such as VVER-1000 and their more advanced versions) that will be the most common type of reactors built domestically and abroad over the next decades producing vast majority of SNF.
- Fast breeder reactors producing plutonium sufficient to refuel themselves and capable to produce additional plutonium for other reactors, if necessary.
- Facilities capable to reprocess all legacy and new spent nuclear fuel to extract plutonium and uranium for further use in fresh fuel for fast reactors (in the nearest future) and thermal reactors (in the more distant future).

This policy sees accumulated civil plutonium as a raw material for nuclear fuel of various types of energy reactors.

This policy is captured in policy and budget planning documents that were adopted in the last five years and cover the period of time until 2030. In addition to policy and budget planning Russia has developed a set of regulations establishing requirements to handling plutonium. Most notable examples of such regulations include:

- NP-098-17 Requirements to Safety of Facilities Manufacturing Nuclear Fuel Containing Plutonium (mandatory regulation)
- NP-080-07 Requirements to Fuel Elements and Fuel Assemblies Containing Uranium-Plutonium (MOX) Fuel for Nuclear Power Plants (mandatory regulation)
- RB-057-10 Safety Guide on Design and Manufacturing of Fuel Elements and Fuel Assemblies with Uranium-Plutonium (MOX) Fuel

[28] Comments of the RF Ministry of International Affairs Regarding the U.S. Report on the Implementation of Arms Control, Non-Proliferation and Disarmament Agreements of May 5, 2019 https://www.mid.ru/web/guest/situacia-vokrug-dogovora-o-rsmd/-/asset_publisher/ckorjLVIkS61/content/id/3633105

There are additional regulations that apply to all nuclear materials, including plutonium, or specific to plutonium.

Funding for the development of new facilities and research is allocated from various sources, including federal budget, Rostom own funds and funding that nuclear sites contribute to funding reserves managed by Rosatom, including reserves intended for management of nuclear waste and decommissioning nuclear sites.

Existing components of the future nuclear energy system include a fleet of thermal reactors generating spent nuclear fuel containing plutonium (for the rate of accumulation of plutonium in spent nuclear fuel see table 1 above), RT-1 reprocessing plant at Mayak, MOX fuel fabrication facility at MCC and BN-800 fast neutron reactor at Beloyarsk NPP.

Plutonium used for fabrication of MOX fuel is extracted from SNF of civil reactors at Russia's single radiochemical plant – RT-1 operated at Mayak. RT-1 is capable of reprocessing SNF from various types of reactors, including NPP reactors, reactors of nuclear submarines and surface ships and research reactors. RT-1 annual design capacity is 400 tons in uranium equivalent. Since its commissioning in 1977 until 2017 RT-1 has processed over 6200 tons of SNF[29]. Based on this figure, as well as the rate of separated plutonium accumulation, one can conclude that on average RT-1 has been working well below its design capacity.

Another radiochemical plant RT-2 is under the development at MCC site. MCC has already developed pilot SNF reprocessing facility that is expected to reach reprocessing capacity of 250 tons/year in 2021[30]. Pilot facility is intended to test new reprocessing technologies and equipment. Data obtained from operation of this pilot facility will serve as a basis for design of the large-scale RT-2 reprocessing facility at MCC. Current reprocessing facility at MCC works with SNF from VVER-1000 reactors. Longer term plans for reprocessing at MCC include development of capabilities to reprocess MOX SNF from BN reactors, as well as irradiated REMIX fuel – new uranium-plutonium fuel to be used in light water reactors (see below).

There is only one nuclear power plant reactor in Russia that is licensed to burn MOX fuel – sodium cooled BN-800 reactor at Beloyarsk NPP in Urals. BN-800 commissioned in 2015 can work at both uranium and mixed uranium-plutonium MOX fuel. First batch of MOX fuel assemblies was loaded into BN-800 in January 2020. It is expected that in January-February 2021 one third of the core will use MOX fuel and in 2022-2023 BN-800 will shift to 100% of MOX fuel in the core. Full core of the MOX fuel contains around 2.3 tons of plutonium. However, plutonium used for BN-800 MOX fuel now comes from the SNF of thermal pressurized water reactors VVER-1000 reprocessed at Mayak and turned into pellet MOX fuel at MCC, not weapons grade plutonium coming from dismantled nuclear weapons.

MOX fuel for BN-800 is manufactured at MCC. Rosatom build MOX fuel fabrication plant in 2011-2014. Original plan was to use this plant for fabrication of MOX fuel from weapons plutonium under PMDA. However, after suspension of the PMDA in 2016 MOX fuel production shifted to plutonium from the SNF of thermal pressurized water reactors VVER-1000. Start up activities and personnel training took several years and first batch for the test load of BN-800 was manufactured only in 2019. Another batch constituting one third of BN-800 core was sent to Beloyarsk NPP in July 2020. Design capacity of the new plant is 400 MOX fuel assemblies per year[31], which is approximately equal to more than two annual loads for BN-800 reactor.

There are two additional large scale projects that are already past the initial R&D phase and have already attracted substantial investments from Rosatom and federal budget. These projects are development of the new REMIX fuel for light water reactors and development of new BREST reactor together with associated fuel cycle facilities.

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[29] http://www.atomeco.org/mediafiles/u/files/2017/materials/04_Kolupaev_D.N._RT_1.pdf
[30] http://www.atomeco.org/mediafiles/u/files/2017/materials/03_GXK___centr_obrashheniya_s_OYAT.pdf
[31] https://sibghk.ru/activity/radiochemical-plant.html

REMIX fuel is a fuel that is made from the reprocessed SNF of light water reactors via adding enriched uranium to fuel mixture. Key benefits of REMIX fuel are lack of separation of uranium and plutonium during reprocessing, fuel characteristics that allow using it in Russian design light water reactors contrary to MOX fuel[32], and large number of regeneration cycles. Fuel assemblies with REMIX fuel have been tested at Balakovo NPP in VVER-1000 reactor. Rosatom investment committee approved the project to develop REMIX fuel manufacturing capabilities in the Summer 2020. It is expected that SCC will manufacture fuel elements and assembles, while MCC will reprocess SNF, produce fuel mixture and pellets. REMIX fuel can potentially provide benefits in terms of plutonium handling as it can redirect SNF flows from the MOX path that requires separation of plutonium to the path that does not require separation of plutonium.

BREST reactor is lead cooled fast neutron reactor using mixed uranium-plutonium nitride fuel. Current plan assumes co-location of the reactor with facilities for reprocessing SNF and manufacturing new fuel at SCC. This is made due to the fact that BREST needs “outside” input of nuclear materials for several start load only, while following loads will be using reprocessed SNF from the reactor itself. Start-up load for BREST reactor requires 2.1 tons of plutonium, while 11,3 tons of plutonium are required until reactor and associate fuel cycle achieve fuel self-sufficiency. It is currently expected that start load for BREST reactor will be made from the SNF of light water reactors, presumably RBMK. However, BREST can use weapons grade plutonium as well. Fuel assemblies for pilot BREST-OD-300 reactor have already been tested in BN-600 reactor. Building for fuel fabrication plant has already been completed and installation of the main technology equipment started in June 2020[33] with expected commissioning in 2022. Rosatom awarded general contract with a total value of 26 billion RUR (approx. 340 million USD as of December 1, 2020) for construction of the reactor in December 2019 with expected commissioning in 2026.

Russia also had several projects involving plutonium that had been either postponed or cancelled. Examples of these projects are development of small modular lead-bismuth-cooled fast reactor capable of using uranium fuel, MOX fuel and uranium-plutonium nitride fuel and sodium cooled fast reactor BN-1200 using recyclable uranium-plutonium nitride fuel. BN-1200 was meant to be the first in series of commercial energy reactors considered promising for domestic needs and export. Although reactor design is well developed, there is no plans on actual construction of such reactors in the nearest decades.

RUSSIA’S REACTION TO THE U.S. PLUTONIUM INITIATIVES

Dilute-and-Dispose Approach to Weapons Plutonium

Russian reaction to the U.S. dilute-and-dispose approach to managing excess weapons plutonium was officially stated in the Russian President’s Decree of October 3, 2016, suspending implementation of PMDA and relatively recently confirmed in the statements of Russian Ministry of Foreign Affairs[34].

Russia sees this approach as non-compliance with provisions of PMDA as the U.S. changed disposition method different from those captured in PMDA (using plutonium for MOX fuel) and had not reconciled this change with Russia as required by PMDA. Russian side also informed the U.S. that Russia is not going to agree with the change in the U.S. approach to disposing excess weapons plutonium.

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[32] Rosatom tested used of MOX fuel in VVER-1000 as part of cooperation with the U.S. on plutonium and made decision not to proceed with VVER-1000 path due to neutron characteristics of MOX fuel and associated safety concerns.

[33] https://tvel.ru/press-center/news/?ELEMENT_ID=8131

[34] President Order #511 of October 3, 2016 On the Suspension of Agreement Between the Government of the United States of America and the Government of the Russian Federation Concerning the Management and Disposition of Plutonium Designated as No Longer Required for Defense Purposes and Related Cooperation and Protocols to This Agreement. URL: http://www.kremlin.ru/acts/bank/41288
Comments of the RF Ministry of International Affairs Regarding the U.S. Report on the Implementation of Arms Control, Non-Proliferation and Disarmament Agreements of May 5, 2019 https://www.mid.ru/web/guest/situacia-vokrug-dogovora-o-rsmd/-/asset_publisher/ckorjLVIkS61/content/id/3633105

Additional concern is captured in multiple articles of Russian experts[35], including those that favor the U.S.-Russian cooperation on the broad range of nuclear security issues. Russian experts see dilute-and-dispose approach as not irreversible and allowing to retrieve weapons plutonium back, which contradicts to PMDA provisions.

It is worth noting that at both official and expert levels Russia does not acknowledge economic or domestic politics rationale behind the decision to use dilute-and-dispose option. Instead, they see this decision as hostile to Russia in a situation, when Russia has already established infrastructure necessary to implement PMDA.

Expansion of Plutonium Pits Production

In January 2020 National Nuclear Security Administration (NNSA) announced that it will proceed with a plan to sharply expand production of plutonium pits. NNSA envisions producing "no fewer than 80 pits per year by 2030," including a minimum of 30 pits per year at Los Alamos National Laboratory and a minimum of 50 pits per year at the Savannah River Site. Currently, "less than 20 per year" are produced, all at Los Alamos.[36]

There is no publicly available Russian reaction to this developments. It is likely that Russia sees no need in the reaction. Pit production contributes to the U.S. capability to maintain deterrence against Russia. Similarly, Russia supports its own deterrence capability through maintaining its own nuclear weapons complex. Due to the differences in approach to maintaining plutonium pits in active nuclear weapons Russia have likely been maintaining proper capabilities at Mayak, while second plutonium pits production facility at SCC was shut down. Russia has invested substantial resources in the upgrade of Mayak facility over the last years (see above) therefore can likely leave the U.S. decision to expand plutonium pits production unnoticed, at least at public level.

SUMMARY

- Russia suspended implementation of the U.S.-Russian Plutonium Management and Disposition Agreement referring to the U.S. incompliance with Agreement provisions and hostile actions towards Russia after conflict over Crimea. Still Russia declared it is not going to use 34 tons of plutonium subject to Agreement for defense purposes. Russia has also established infrastructure necessary to burn plutonium via using it for MOX fuel – MOX fuel production facility at Mining and Chemical Combine and BN-800 reactor suitable to burn MOX fuel. It is expected that BN-800 will have 100% core loaded with MOX fuel in 2022-2023. However, this fuel uses plutonium coming from reprocessed SNF of Russian light water reactors, not from weapons plutonium. If parties manage to reconcile disagreements over PMDA Russia will be able to jump start disposal of weapons plutonium subject to Agreement.
- Russia substantially downsized legacy nuclear fuel cycle complex that produced weapons plutonium. All plutonium production reactors and radiochemical facilities reprocessing SNF fuel from these reactors were shut down. Russia also shut down one of two plutonium pits manufacturing facilities at SCC, while maintaining and upgrading second one at Mayak to maintain deterrence capabilities.
- Russia's approach to managing civilian plutonium is driven by the nuclear energy policy aimed at development of closed nuclear fuel cycle. This policy sees Russian inventory of plutonium as a valuable reserve that can be used to fuel future nuclear power plants. Following this policy Russia has already established industrial scale MOX fuel production capability and proceeds with transitioning first reactor – BN-800 fast neutron reactor at Belayarsk NPP – to full MOX load. This

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[35] E.g., see Gennady Pshakin, Russian-American Agreement to Dispose Plutonium Declared Excess to Weapon Needs – Alternatives and Prospects. Yaderny Kontrol, Issue #4 (477), April 2016 (in Russian) http://www.pircenter.org/media/content/files/13/14624618110.pdf

[36] https://fas.org/blogs/secrecy/2020/01/nnsa-pits/

reacto will burn approximately two tons of separated civilian plutonium on the annual basis. Russia has also started developing two technologies that are going to involve plutonium in civil nuclear energy production without separating plutonium from uranium – REMIX fuel technology for light water reactors, as well as BREST reactor that is going to burn mixed uranium-plutonium nitride fuel.

APPENDIX – TABLE 2: STATUS OF RUSSIAN PLUTONIUM INFRASTRUCTURE

Facility	Site	Role in Pu Management	Pu Grade	Operational Status	Note
A reactor	Mayak	Plutonium production	Weapons grade	Shut down	
IR-AI reactor	Mayak	Plutonium production	Weapons grade	Shut down	
AV-1 reactor	Mayak	Plutonium production	Weapons grade	Shut down	
AV-2 reactor	Mayak	Plutonium production	Weapons grade	Shut down	
AV-3 reactor	Mayak	Plutonium production	Weapons grade	Shut down	
AD reactor	MCC	Plutonium production	Weapons grade	Disposal in progress	
ADE-2 reactor	MCC	Plutonium production	Weapons grade	Disposal in progress	Shut down with the U.S. support
ADE-1 reactor	MCC	Plutonium production	Weapons grade	Disposal in progress	
BN-600 commercial fast reactor	Beloyarsk NPP	Plutonium production and burn	Reactor grade	Operation	- Produces Pu as by product and capable to produce additional plutonium to cover other reactors' needs - Sodium cooled commercial power reactor mostly fueled by U-fuel and limited number of experimental MOX and NMUP fuel assemblies loaded for irradiation tests
EI-2 reactor	SCC	Plutonium production	Weapons grade	Disposed	
I-1 reactor	SCC	Plutonium production	Weapons grade	Shut down	

ADE-3 reactor	SCC	Plutonium production	Weapons grade	Shut down	
ADE-4 reactor	SCC	Plutonium production	Weapons grade	Disposal in progress	Shut down with the U.S. support
ADE-5 reactor	SCC	Plutonium production	Weapons grade	Disposal in progress	Shut down with the U.S. support
BN-800 commercial fast reactor	Beloyarsk NPP	Plutonium production and burn	Reactor grade	Operation	- Reproduces Pu to be used for refueling the reactor and capable to produce additional plutonium to cover other reactors' needs - Sodium cooled commercial power reactor fueled with both uranium and MOX fuel. Full transitioning to MOX is expected in several years
BREST-OD-300 demonstration fast reactor	SCC	Plutonium production Use of U-Pu-fuel	Reactor grade	Construction in progress	- Reproduces plutonium to be used for refueling the reactor-Lead-cooled fast reactor fueled with U-Pu fuel (NMUP)- Part of demonstration complex constructed at SCC to trial on-site closed fuel cycle
SNF wet storage facility	Mayak	SNF storage	Reactor grade	Operation	
SNF wet storage facility	MCC	SNF storage	Reactor grade	Operation	
SNF dry storage facility	MCC	SNF storage	Reactor grade	Operation	
Radiochemical facility	Mayak	Plutonium separation	Weapons grade	Disposal in progress	
Radiochemical facility	MCC	Plutonium separation	Weapons grade	Disposal in progress	
Radiochemical facility	SCC	Plutonium separation	Weapons grade	Disposal in progress	

RT-1 radiochemical facility	Mayak	Plutonium separation (SNF reprocessing)	Reactor grade	Operation	RT-1 is dual purpose (civil/defense facility): reprocesses SNF from commercial and research reactors and reactors of civil nuclear powered vessels, as well as SNF of nuclear submarines and legacy HEU SNF of plutonium production reactors (Pu from HEU fuel is not weapons grade).
RT-2 radiochemical facility/ Experimental Demonstration Center	MCC	Plutonium separation (SNF reprocessing)	Reactor grade	Construction in progress	RT-2 construction project includes two stages. Stage 1, construction of laboratory for piloting SNF reprocessing, is completed. Completion of stage 2, construction of full scale SNF reprocessing facility is expected in 2020. Rosatom also stated that the facility can be expanded in the future by adding standard modules, but announced no specific expansion plans.
SNF reprocessing Module	SCC	Plutonium separation (SNF reprocessing)	Reactor grade	Construction in progress	Part of demonstration complex constructed at SCC to trial on-site closed fuel cycle.
Chemical metallurgy facility	Mayak	Pit fabrication	Weapons grade	Operation	
Chemical metallurgy facility	SCC	Pit fabrication	Weapons grade	Disposal in progress	
Mayak Fissile Material Storage Facility	Mayak	Separated plutonium storage	Weapons grade	Operation	Stores 25 tons of pits subject to PMDA.
Storage facility for Pu dioxide	MCC	Separated plutonium storage	Weapons grade	Operation	Stores 15 tons of Pu dioxide separated from irradiated fuel of MCC and SCC reactors shut down within the framework of the U.S.-Russian cooperation on plutonium production reactors. 9 of 15 tons are subject to PMDA.
Storage Facility	Mayak	Separated plutonium storage	Weapons grade	Operation	Stores weapons grade plutonium outside weapons that is not subject to U.S.-Russian agreements.

Storage Facility	Mayak	Separated plutonium storage	Reactor grade	Operation	Mayak stores plutonium separated from reactors' fuel at RT-1 radiochemical facility and awaiting for use in U-Pu fuel fabrication
Pilot MOX fuel fabrication facility (Paket)	Mayak	U-Pu fuel fabrication	Reactor grade	Operation	This small capacity facility is operable, but is not used on a regular basis.
MOX fuel fabrication facility	MCC	U-Pu fuel fabrication	Reactor grade	Operation	Fabricates MOX fuel for BN-800
Pilot MNUP/REMIX fuel fabrication facility	SCC	U-Pu fuel fabrication	Reactor grade	Construction in progress	Facility constructed at SCC site to fabricate experimental MNUP fuel fast reactors needed for R&A. SCC plans to upgrade fabrication facility to convert it on piloting fabrication of REMIX fuel for VVER-1000 by 2023 using fuel pellets supplied by MCC
Fuel fabrication and refabrication module	SCC	U-Pu fuel fabrication	Reactor grade	Construction in progress	Part of demonstration complex constructed at SCC to trial on-site closed fuel cycle